Two New Pelagic Tunicates from the Eastern Pacific Ocean[1]

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The species here named *Cyclosalpa strongylenteron* was first noted in a plankton sample taken at station 194 of Scripps Institution of Oceanography (SIO) cruise Shellback (SB). This species has since been identified from seven other Shellback stations and from four Marine Life Research (MLR) stations.

Cyclosalpa pinnata quadriluminis, though not previously named, has been described by Ihle (1910: 18–19) and Komai (1932: 69–70) as an aberrant form. In the MLR area, which extends from the Columbia River to the southern tip of Baja California and four hundred miles out to sea, this subspecies has been taken in such numbers and so consistently that a re-examination of these presumed aberrant individuals is felt necessary. Here for the first time it is named and reported in large numbers.

The following material, upon which part of the descriptions herein are based, has been deposited in the U. S. National Museum:

1. *Cyclosalpa strongylenteron*, aggregate generation, HOLOTYPE, 1 specimen U.S.N.M. 11281.

2. *Cyclosalpa strongylenteron*, solitary generation (embryo), PARATYPE, 1 specimen U.S.N.M. 11282.

3. *Cyclosalpa strongylenteron*, aggregate generation, PARATYPES, 10 specimens U.S.N.M. 11283.

4. *Cyclosalpa pinnata quadriluminis*, aggregate generation, HOLOTYPE, 1 specimen U.S. N.M. 11284.

5. *Cyclosalpa pinnata quadriluminis*, aggregate generation, PARATYPES, 5 specimens U.S. N.M. 11285.

I wish to express my thanks to Drs. M. W. Johnson and C. L. Hubbs for their advice in preparing this manuscript and to Dr. Paul Friedlander for his assistance in naming the animals.

Cyclosalpa strongylenteron new species

The aggregate generation of this species was first recognized in a sample taken at SIO SB station 194, 0° 01.5′ S and 99° 08.5′ W. In a subsequent preliminary survey it was found at seven other SB stations and at four MLR stations (Fig. 8). Embryos of the solitary generation have been observed at MLR stations 11–120.80 and 35–110.60. The details of these individuals were almost completely obscured by a granular appearing mantle but the stolons were well preserved and the details of well-developed aggregate individuals could be readily determined.

Cyclosalpa strongylenteron, aggregate generation

The aggregate generation of this species shows characters quite similar to those of the aggregate generation of four other species. The musculature resembles that of *C. pinnata*, the major difference being the presence in *C. strongylenteron* of a large dorsal visceral muscle and only two sphincters on the lower lip of the oral opening. It resembles *C. affinis* in the

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convoluted formation of the dorsal tubercle and the looped nature of the gut. The caecum is large and projects posteriorly much like that found in *C. bakeri*. The arrangement of the testis is reminiscent of that found in *C. virgula* in that it extends back from the center of the gut loop in a long slender pouch.

The terminal openings and long muscular peduncle differentiate this species from all other members of the genus *Cyclosalpa* except *C. pinnata* and *C. bakeri*. The absence of light organs differentiates *C. strongylenteron* from *C. pinnata* and the convoluted dorsal tubercle and formation of the body muscles distinguish it from *C. bakeri*.

Body: (Fig. 1) The general shape of the body is much like that of the aggregate generation of *C. affinis*. The size is from 2 to 100 mm. The test is soft, thick and very easily stripped from the animal. The atrial and oral openings are terminal. Many specimens have the dorsal portion of the body covered with a granular material which makes the details of structure difficult and sometimes impossible to see.

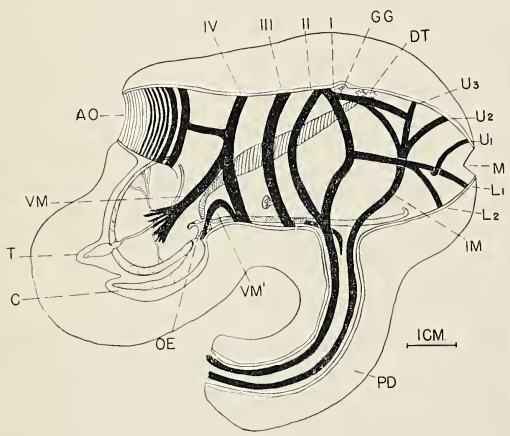

FIG. 1. *Cyclosalpa strongylenteron*, aggregate generation. AO, Atrial opening; C, caecum; DT, dorsal tubercle; GG, dorsal ganglion; IM, intermediate muscle; L_1-L_2, sphincters of the lower lip; M, oral opening; OE, oesophagus; PD, peduncle; T, testis; U_1-U_3, sphincters of the upper lip; VM, dorsal visceral muscle; VM′, ventral visceral muscle; I-IV, body muscles.

Light organs: Light organs are absent.

Muscles: (Fig. 1) There are four body muscles arranged much like those of *C. pinnata*. All the body muscles are continuous across the dorsal midline, while ventrally only muscle IV is continuous with its mate from the opposite side. Body muscles I and II are in contact both dorsally and ventrally, extending ventrally into the peduncle as the paired posterior peduncle muscles. Muscle IV gives off two branches, the first the ventral visceral muscle, originates ventrolaterally and extends back along the intestine. The second, the dorsal visceral muscle, originates just below the lateral midline and extends posteriorly and ventrally into the center of the loop formed by the gut. Just above the origin of the dorsal visceral muscle the atrial retractor attaches to muscle IV; from whence it extends back to insert into the first, and strongest, atrial sphincter. The atrial sphincter muscles, which number about 13, are unbranched and form complete loops.

The oral musculature closely resembles that of the aggregate *C. pinnata*. There is a single oral retractor which passes forward, external to the intermediate muscle, and bifurcates to form the two sphincters of the lower lip. The upper lip has three sphincters, the first originates from the first sphincter of the lower lip just after its formation. The second and third originate from the intermediate muscle just above the point where it is crossed by the oral retractor. From the point of origin of the sphincters the intermediate muscle bends back to attach to the dorsal portion of the first body muscle. The horizontal muscle extends from the intermediate muscle, just before the junction of that muscle with body muslce I, to a point on the third sphincter of the upper lip about midway between its origin and the dorsal midline. Ventrally the intermediate muscle joins its mate from the opposite side to form a V which extends into the peduncle as the anterior peduncle muscle.

Dorsal tubercle: (Fig. 2) The dorsal tubercle is much twisted, forming an almost closed irregular ring.

Internal structure: The gut approaches in shape most closely that found in the aggregate generation of *C. affinis*. It forms a large loop which lies outside the body in a large protuberence, the postabdomen. The wide

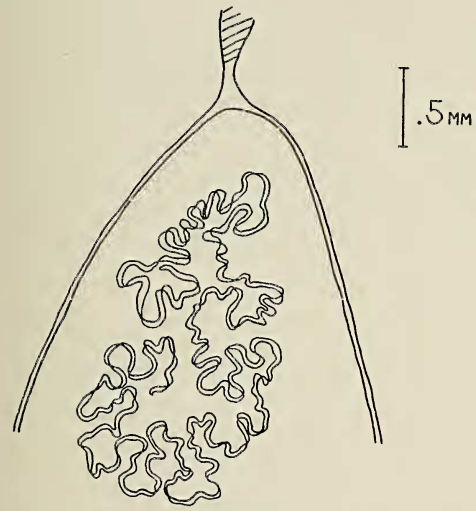

FIG. 2. *Cyclosalpa strongylenteron*, dorsal tubercle.

flairing oesophageal opening is on the right side of the body at the base of the gill. The anus is on the left side slightly above the oesophageal opening. There is no stomach-like enlargement of the intestine. The caecum, similar to that in *C. bakeri*, is extremely well developed, originating just behind the opening of the oesophagus and extending back at least as far as the end of the postabdomen. The duct of the intestinal gland, which empties into the intestine just after the origin of the caecum, passes across the gut loop and branches over the distal portion of the intestine. The endostyle extends from below the bifurcation of the oral retractor to the area of the oesophageal opening. The heart is below and slightly anterior to the opening of the oesophagus. The ganglion is quite similar to that of the aggregate *C. pinnata*. The testis is in a slender pouch extending posteriorly from the region midway around the gut loop. It may be as much as three times as long as shown in Figure 1. The vas deferens extends across the gut loop and up into the region just anterior to the atrial opening. The ovary lies just behind muscle III. The oviduct passes forward to a point near the anterior border of that muscle.

Cyclosalpa strongylenteron, solitary generation

The solitary generation of this species has to my knowledge been taken only twice: seven embryo individuals, with well-developed stolons, at MLR station 11–120.80 and one embryo at MLR station 35–110.60. These all have the same granular appearance seen in some aggregate individuals. Here the granular appearance is so well developed that it conceals many details of structure. So little of the details of the body muscles of the solitary generation can be determined, due to concealment by this granulation, that it is impossible to compare them, except in a general way, with those of existing species.

Body: (Fig. 3) Length 25 mm. The body is cylindrical with the oral and atrial openings terminal. There are two well-developed ventral languets below and just posterior to the oral opening. The test appears more ridged than that of the aggregate form.

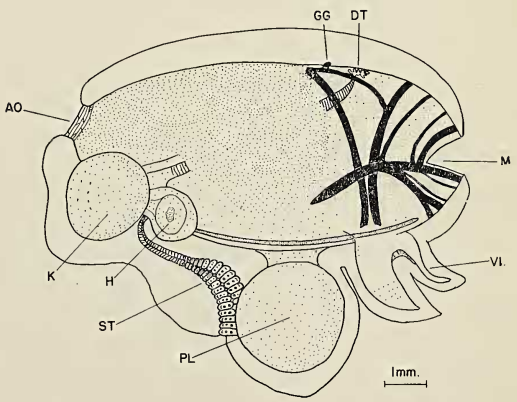

FIG. 3. *Cyclosalpa strongylenteron*, embryo of solitary generation. AO, Atrial opening; DT, dorsal tubercle; GG, dorsal ganglion; H, heart; K, eleoblast; M, oral opening; PL, placenta; ST, stolon; VL, ventral languets.

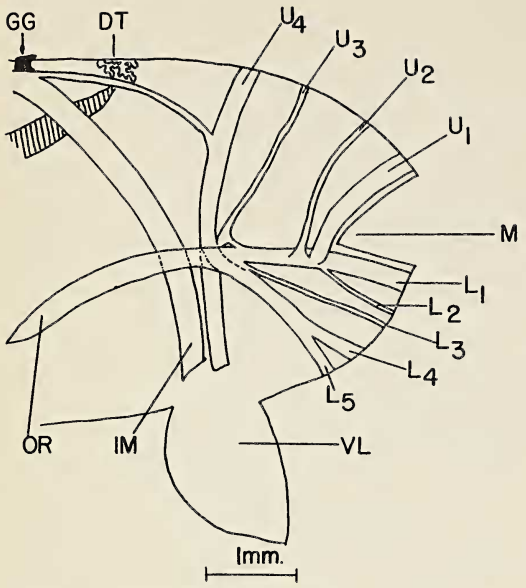

FIG. 4. *Cyclosalpa strongylenteron*, solitary generation, oral musculature. DT, Dorsal tubercle; GG, dorsal ganglion; IM, intermediate muscle; L_1-L_5, sphincters of the lower lip; M, oral opening; OR, oral retractor; U_1-U_4, sphincters of the upper lip; VL, ventral languet.

Light organs: It could not be determined whether or not light organs were present.

Muscles: (Figs. 3 and 4) There appear to be seven body muscles arranged in a manner much more complicated than in other species of the genus. All the body muscles are interrupted ventrally and appear to form two bundles dorsally.

The oral musculature could be determined on the embryo taken at station 35–110.60, it is more complicated than that of any of the other cyclosalpas (Fig. 4). There are five sphincters on the lower lip and four on the upper lip. There is a single oral retractor which passes forward external to the intermediate muscle and bifurcates into a dorsal and a ventral portion. The dorsal portion continues forward to form the first ventral oral sphincter (L_1), midway along its course a small muscle branches off to form L_2. The ventral branch of the oral retractor gives off a thin branch, just after its formation, which continues forward to form L_3. The remaining portion of the ventral branch then bifurcates to form L_4 and L_5. The first two sphincters of the upper lip, U_1 and U_2, originate from the first sphincter of the lower lip midway between its origin and the origin of L_2. U_3 is formed from two portions, one coming from U_4 just as it emerges from under the oral retractor and the other from the oral retractor just before its bifurcation. A branch from the ventral portion of the oral retractor and an independent muscle which runs parallel to the intermediate muscle join under the oral retractor and continue dorsally as U_4. Near the dorsal midline U_4 gives off a branch which turns posteriorly and joins the intermediate muscle in the region of the dorsal ganglion.

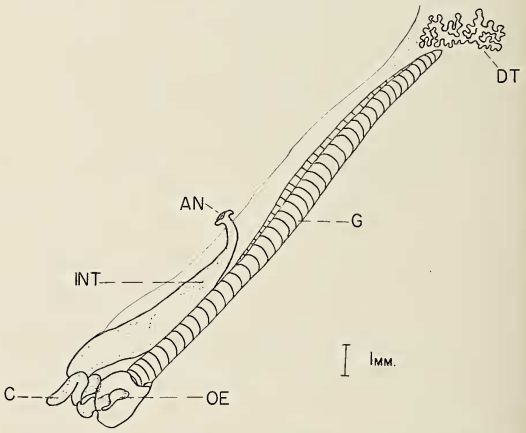

FIG. 5. *Cyclosalpa strongylenteron*, gill and gut of solitary generation. AN, Anus; C, caecum; DT, dorsal tubercle; G, gill; INT, intestine; OE, oesophageal opening.

The atrial musculature appears to be much like that of the solitary *C. affinis*.

Dorsal tubercle: The dorsal tubercle is almost identical with that of the aggregate form, a condition approached but not obtained in *C. affinis*.

Internal structure: The gut, as is typical of all solitary cyclosalpas, is dorsal to the gill, but uniquely it overlays just slightly less than half the length of the gill (Fig. 5). The wide flairing oesophageal opening lies at the ven-

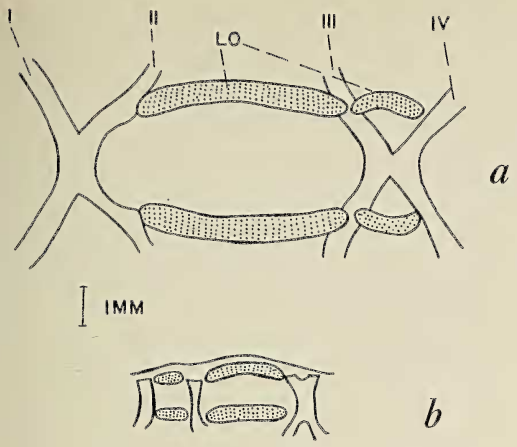

FIG. 6. *a*, *Cyclosalpa pinnata quadriluminis*, aggregate generation, dorsal view showing arrangement of body muscles and light organs. LO, Light organs. *b*, *Cyclosalpa pinnata* aberrant form after Ihle (1910).

tral posterior end of the gill. The narrow oesophagus forms a single spiral before continuing into the intestine. The first part of the intestine is enlarged into what may be called a stomach. Two blunt caeca, of equal size, project posteriorly from their origin on the intestine immediately behind the oesophagus, on either side of the midline. The endostyle extends from the area of the oesophageal opening to the anterior part of the body. The ganglion, much like that of the solitary *C. pinnata*, has a well-developed, horseshoe-shaped eye. The heart lies anterior and ventral to the oesophageal opening. The stolon originates near the heart and extends forward to a point half way up the body, where it turns directly away from the body.

Distributional data on *C. strongylenteron* are very scattered since the species has been identified from only 12 localities. The range is from off the coast of Peru to off the coast of Baja California (Fig. 8). Since the surface temperatures at these localities ranged from 14.5 ° C. to 28° C. the species appears to be eurythermal. More information on its vertical distribution, however, may indicate a more limited temperature range.

Cyclosalpa pinnata quadriluminis
new subspecies

Cyclosalpa pinnata (Forskål), 1775, the first of the salps described, is probably the best known species of the family. It appears also to be the most variable, inasmuch as it includes at the present time two subspecies in addition to the one described in this paper.

In his report on the Siboga collections Ihle (1910: 18–19) figured one aberrant specimen of the aggregate generation of *C. pinnata* that had two pairs of light organs instead of the usual single pair (Fig. 6*b*). This aberrant type was also reported by Komai (1932: 69–70), who found a single specimen in the vicinity of Seto, Japan.

The aberrant type, which is here given the name *Cyclosalpa pinnata quadriluminis*, occurs consistently in the plankton samples taken by Scripps Institution of Oceanography in conjunction with the MLR program. The aggregate generation of *C. pinnata* has been found in 49 of 1,158 hauls examined. From these hauls 104 specimens of *C. pinnata polae* and 620 specimens of *C. pinnata quadriluminis* have been recorded. No specimens of the aggregate generation of *C. pinnata pinnata* have been observed. The subspecies *quadriluminis* agrees in all respects with the subspecies *polae* except that there is an additional pair of light organs present in *quadriluminis*.

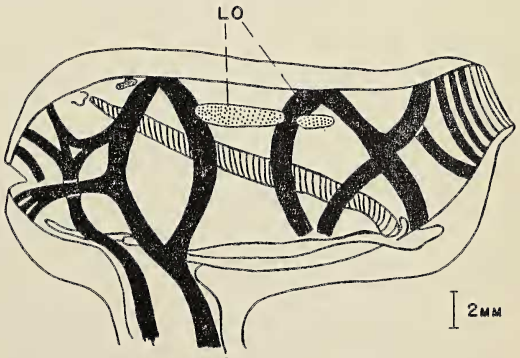

FIG. 7. *Cyclosalpa pinnata quadriluminis*, aggregate generation. LO, Light organs.

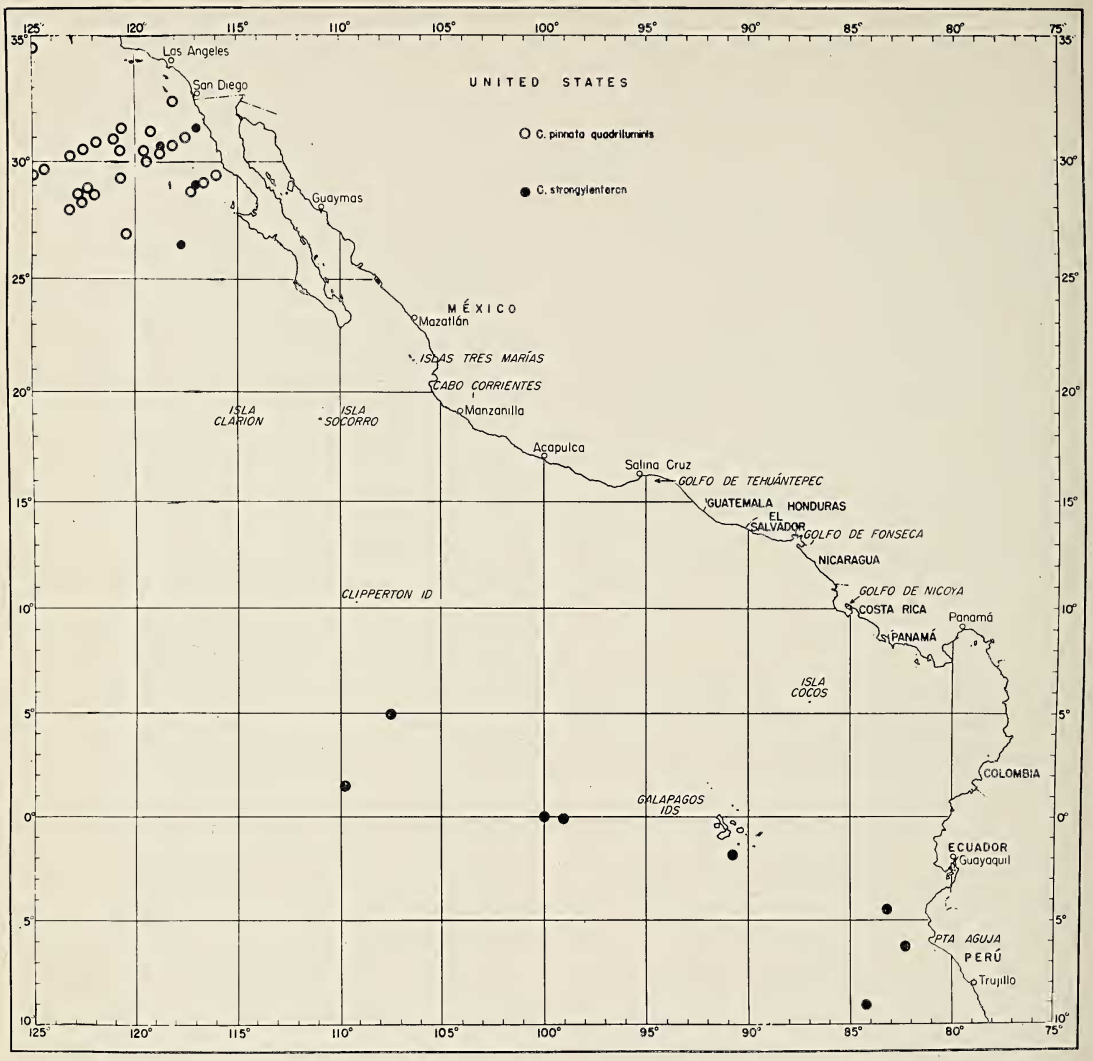

FIG. 8. Chart showing distribution of *Cyclosalpa strongylenteron* and *Cyclosalpa pinnata quadriluminis.*

Cyclosalpa pinnata quadriluminis, aggregate generation

Body: (Fig. 7) The body exhibits the typical shape of the aggregate generation of *C. pinnata* but the test is thicker than generally found in the species. The size of the specimens ranged from 10 to 50 mm.

Muscles: The four body muscles are all continuous dorsally. Muscles I and II and muscles III and IV are fused for a short distance over the dorsal midline (Fig. 6*a*). In the specimens examined this fusion does not extend as far as indicated for *polae* by the figures of Sigl (1912: 66–74) and Sewell (1926: 72). Body muscles I and II fuse ventrally and continue into the peduncle as the posterior peduncle muscles. The single oral retractor branches to form the three sphincters of the lower lip. Of the three dorsal oral sphincters the first is an independent muscle while the second and third originate from the intermediate muscle just above the point where

the oral retractor crosses it. Dorsally the intermediate muscles unite with the first body muscle; midventrally they join and continue into the peduncle as the anterior peduncle muscles.

Internal structure: The internal structure appears to be identical with that of the aggregate *C. pinnata*. The gut lies below the endostyle, which extends forward to the area of the third ventral oral sphincter. The dorsal tubercle is of typical horseshoe-shape and the ganglion with the eye is typical of the species.

Light organs: (Fig. 6*a*, *b*) It is on the variation found in the light organs that this subspecies is based. The usual pair of light organs is present between muscles II and III but there is an additional pair situated between muscles III and IV. The second pair of light organs is smaller than the first, usually about one third as large.

No characters have been found in individuals of the solitary generation examined which might indicate that they belong to this subspecies. The specimens examined have been typical of the solitary form of *C. pinnata polae*.

Except for the records of Ihle and Komai from the Molucca Sea and off Seto, Japan, respectively, the known distribution of *C. pinnata quadriluminis* at the present time is confined to the area off the California coast south of Point Conception and north of Sebastián Viscaíno Bay off Baja California (Fig. 8). In the area off western North America under consideration the subspecies is six times as common as subspecies *polae*. No information is available on the vertical distribution of the subspecies.

SUMMARY

Two members of the genus *Cyclosalpa* have been described from the eastern Pacific Ocean. *C. strongylenteron*, new species, has been taken in 12 localities ranging from off the coast of Peru to off the coast of Baja California. *C. pinnata quadriluminis* new subspecies, previously noted by Ihle and Komai is here named and reported in large numbers for the first time. The range of this subspecies, except for the two specimens previously reported, is off southern California and northern Baja California.

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